Pakistan J. Zool., vol. 44 (3), pp. 787-798, 2012.

Habitat Analysis and Population Estimates of Three Falcon Species, Red-headed Merlin (*Falco chicquera*), Common Kestrel (*Falco tinnunculus*) and Saker Falcon (*Falco cherrug)*, Inhabiting District Chakwal, Pakistan

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Abstract.- Nine falcon species are reported from various parts of Pakistan; some of these are residents, some winter visitors, some vagrants and others passage migrants. However, very little studies exist about their population and ecology in the country. The present study, therefore, investigated habitat analysis and population status of three falcon species; red-headed merlin *Falco chicquera*, common kestrel *Falco tinnunculus* and saker falcon *Falco cherrug*, in district, Chakwal Pakistan. Eight potential sampling sites were selected through surveillance surveys. Line transects were established in the selected sites for data collection and monthly visited from May 2009 to June 2010. For habitat analysis, data were recorded about trees using "Point-centered quarter" method, while shrubs and herbs were estimated using "quadrate method" and analyzed in terms of density and frequency of trees, shrubs and herbs, and "Importance Value Index" (IVI) for tree species. Red-headed merlin was found in five sites with average population of 0.238 ± 0.06 birds /km^2, common kestrel in five sites with mean density of 0.246 ± 0.05 birds /km^2, whereas saker falcon in only two sites having average density of 0.245 ± 0.06 birds /km^2. Red-headed merlin and saker falcon were found resident while common kestrel was winter visitor plus resident in the study area.

Key words: Chakwal, falcons, Falco Cherrug, red-headed merlin, common kestrel, population.

INTRODUCTION

Falcons belong to the order Falconiformes and genus *Falco* consists of 37 species and 17 sub-species (Collar *et al.,* 1994*).* They are placed at the top of the food chain and are also good indicators of habitat quality since these long lived birds can only survive in habitat offering sufficient food and nesting sites. They all are medium to large -sized birds of prey with wing span ranging from 55 to more than 125 cm and body weight from 28 to 2100 g (Kemp and Newton, 2003).

Nine falcon species are reported from Pakistan, including lesser kestrel, common kestrel, saker falcon, peregrine falcon, merlin, Eurasian hobby, red-headed merlin, laggar falcon, and sooty falcon (Roberts, 1991; Ahmed, 2003; Naoroji, 2006). Red-headed merlin (*Falco chicquera*) is a rare resident bird in Punjab and Sind provinces. It is found in desert boundary regions of Tharparker and Cholistan, Rawal Lake (Islamabad), Mianwali, Lal Sohanra near Bahawalpur (Punjab), and also thinly distributed in Kohat and Peshawar districts (Khyber PakhtoonKhwa). Common kestrel (*Falco tinnunculus*) is resident and breeds in the mountain tracts of Pakistan; also a winter migrant to the plains. It occurs in Balochistan; in Zhob, Chaman, Quetta, Sibi, Kalat and Chaghi. It is a winter visitor to Dera Ghazi Khan and Salt range foothill zone in Punjab, breeds in Murree hills, and a winter visitor throughout the Khyber Pakhtoonkhwah, also seen in Gilgit, Shayok and Indus valleys of Bultistan (Roberts, 1991). Saker falcon (*Falco cherrug*) is a winter visitor to Pakistan, an uncommon visitor to Balochistan, and Indus delta in Sindh. In Punjab province, it is a winter visitor to mountain regions and foothills around Mianwali and Attock districts, also seen around Rawal Lake (Islamabad), but not recorded in the Potohar plateau. In the province of Khyber Pakhtoonkhwah, it is a winter visitor throughout the province (Argandival, 1983; Robers, 1991).

District Chakwal is an important ecological

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0030-9923/2012/0003-0787 $ 8.00/0

area, included in Potohar Plateau, located at the junction of Potohar and the Salt Ranges in Punjab province. There are numerous informal reports about the occurrence of some falcon species in the area; however, no formal scientific population studies are available. The current study was, therefore, designed to analyze habitat characteristics and estimate population of three falcon species inhabiting the study area.

MATERIALS AND METHODS

Study area

The current study was conducted in district Chakwal (32° 56' 0" N, and 72° 52' 0" E), Punjab (Fig. 1), which is semi-arid area having a diversity of flora and fauna. The district is divisible in four small administrative units or Tehsils *viz.*, Chakwal, Talagang, Choa Saiden Shah and Kallar Kahar. It possesses two types of range ecosystems; Salt Range in southern part and Potohar Range in northern part. There are cultivated flatlands, inter-spread with network of rivers and rain water "nallas", dry lands having crests and troughs, thorn forests, wetlands and also few mountains of the Salt Range.

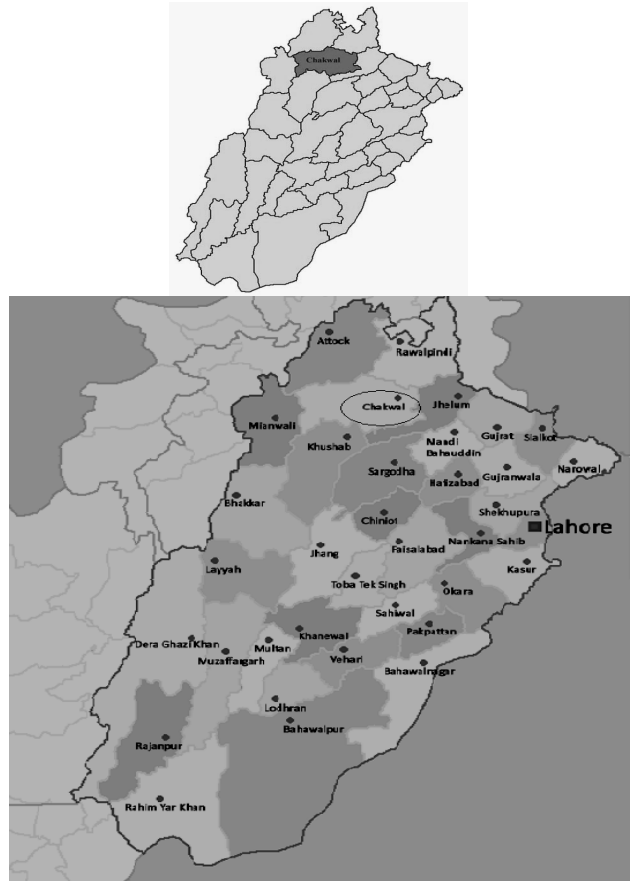

Fig. 1. A map of Punjab province (Pakistan), showing location of study district; Chakwal (highlighted/circled), located in the north of Punjab.

Study design

Surveillance surveys were conducted on a motor vehicle randomly through the wild areas of the district for determining the distribution of falcon species and selection of potential habitat sites. On the basis of these surveys and also the information collected from local residents, eight potential study/sampling sites were selected covering a total area of 6524km^2 in all the four Tehsils of the district, each study site having an area of 4km^2 (Fig. 2, Table I). Four of these sites were located in Tehsil Chakwal itself, two in Tehsil Talagang, and one each in Tehsil Choa Saiden Shah and Kallar Kahar (Fig.2). Selected sampling sites were visited on monthly basis for data collection from May 2009 to June 2010.

Habitat analysis

Potential habitat of the eight selected sites was evaluated for its utilization by the various falcon species by collecting data about trees, shrubs and herbs occurring over there. Plant species including trees, shrubs and herbs were identified and their data were recorded. Density of trees was calculated by using "Point Centered Quarter" method (Cottom and Cartis, 1956). In each study site, two parallel line transects were established. Each transect was 2000m long and 400m wide on either side and the two line transects were separated from each other by a distance of 400m. In each transect, seven points were marked at a distance of 250m, whereas randomly three of those points were used on each transect for collection of tree data. Recorded data were used to find out absolute density, relative density, absolute frequency, relative frequency, absolute cover, relative cover and importance value index (IVI) of tree species in each

Table I.- Some details of the eight selected study sites in Chakwal district for the current study period.

Study sites	Name of place	GPS location	Elevation (m)	Habitat type	Water source
I	Dhoke Chatal (Chakwal)	N 32º58' 0.00" E 72º55' 26.5"	503	Mixed	Barsati nalla
II	Dhoke Wadhan (Chakwal)	N 32º3' 27.17" E 72º57' 41.07"	515	Open cultivated fields	Barsati nalla
III	Punjain (Chakwal)	N 32º53'38.12" E 72º59 50.62"	473	Mixed	Barsati nalla
IV	Jabairpur (Chakwal)	N 32º55'09.2" E 72º53'34.2"	512	Mixed	Rain water pond and Barsati nalla
V	Karangli hill (Choa.S.S)	N 32º45'35.3" E 73º01'48.8"	1092	Hilly and Forest	Barsati nalla and natural springs
VI	Chumbi (Kalar Kahar)	N 32º 46'14.9" E 72º 43'12.3"	638	Mixed	Barsati nalla and natural springs
VII	Chinji (Talagang)	N 32º 42'29.5" E 72º22'17.2"	697	Mixed	Rain water ponds
VIII	Chaman Samsal (Talagang)	N 32º 57'03.0" E 72º 18'48.4"	468	Open ,low vegetation.	Rain water ponds

study site. For tree species following formulae were used:

$$\text{Relative Density (tree species)} = \frac{\text{Quarter with a species}}{\text{Total number of quarters}} \times 100$$

$$\text{Frequency (tree species)} = \frac{\text{Number of sample points with a species}}{\text{Total number of sample point}} \times 100$$

$$\text{Relative frequency (tree species)} = \frac{\text{Absolute frequency of a species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative cover (tree species)} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$$

IVI = Relative density + Relative frequency + Relative cover

Shrubs and herbs of the study area were identified by using Quadrate Method (Emlen, 1956; Schemnitz, 1980). For shrub species, quadrates of 4m x 4m were used and for herb species quadrates were of 1m x 1m sizes. Six quadrates were laid out randomly in each study area and recorded data were used to calculate density, relative density, frequency and relative frequency for all the shrubs and herb species in the selected study sites by using the formulae;

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrate}}$$

$$\text{Frequency} = \frac{\text{Number of Quadrate with a species}}{\text{Total number of Quadrate}} \times 100$$

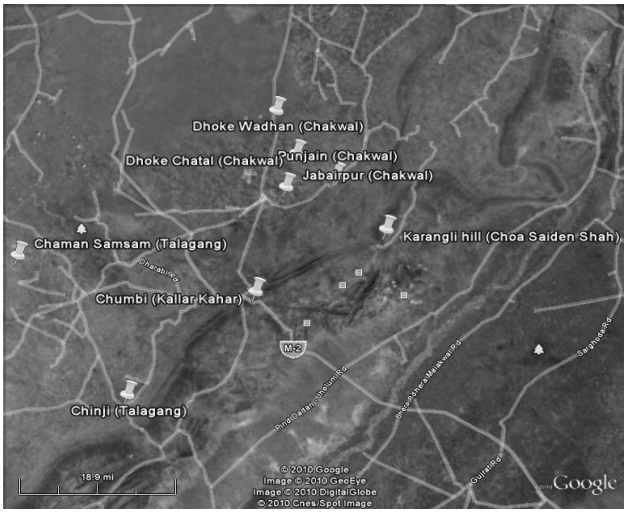

Fig. 2.A satellite map of the study area, showing location of eight selected study sites in district Chakwal (modified from Google Earth).

Population estimation

Populations of falcon species inhabiting the

study area were estimated by using line transect method. In each selected site, two parallel line transects (I and II) were traveled continuously either on foot or on a motorcycle driven at a speed of 10-25 kilometer per hour (km/hr) following Kochart (1986), Milsap and LeFranc (1988). Each transect was two kilometers long and 400 meters wide on either side. The two parallel transects were separated from each other by a distance of 400 meters. A binocular (Olympus, 10 x 50 DPSI) and a digital camera (Sony 7.2 mega pixel) were used to identify the different falcon species in the field according to Roberts (1991) and Naorogi (2006). Population density of the individual falcon species were calculated by using the formula;

$$D = \frac{\sum n}{L \times 2W}$$

Where, D represents estimated density, n, numbers of birds sighted, W is the width of the transect and L represents length of the particular transect.

Information from local residents

Local residents (farmers working in the fields and shepherds) were approached to collect information about the numbers and sightings of the various falcon species in their localities by showing them photographs / pictures of the species. Numbers of each falcon bird seen by the locals and shepherds were recorded for later analysis and comparison.

Statistical analysis

Data obtained regarding the population density of the falcon species were analyzed statistically using One-way Analysis of Variance (ANOVA).

RESULTS

Habitat analysis

Habitat of each falcon species was analyzed by estimation of tree, shrub and herb species. Among various tree species occurring in the study area, *Acacia modesta* was found in seven sites, however, its highest IVI (149.11 and 101.60) was calculated at two sites; V and VII, respectively (Table II). *Acacia nilotica* was found at all eight selected study sites. One falcon species, red-headed merlin, was found mostly associated with *Acacia nilotica* tree species for utilization of nests for breeding purpose. Similarly, *Zizyphus moritiana* was found in all the eight study sites. However, this tree species was not utilized by any falcon species for nesting. On the contrary, *Tamarix aphylla* species was found in only two of the sampling sites I and III with an IVI of 11.82 and 18.71, respectively, and it was prefered for utilization of nests by common kestrel (Table II).

Aaverage highest frequency of shrubs was found in site-V (49.99±9.12) while it was lowest in site-II (33.33±6.80) (Table III). The highest average shrub density was recorded in site-V (0.76±0.24 /4m^2) and lowest (0.53±0.12/4m^2) in site-III. In eight selected study sites, a total of nine shrub species were recorded; two occurred in seven study sites viz. *Ziziphus nummularia* (I, II, III, V, VI, VII and VIII) and *Calotropis procera* (I, II, III, IV, VI, VII and VIII) with variable density and frequency whereas *Dodonaea viscosa* and *Ricinus communis* were found in only one sampling site (V) (Table III). These results indicated *Zizyphus nummularia* and *Calotropis procera* as major shrub species in the seven potential habitat sites of falcon species.

A total of 23 herb species were recorded from all selected sampling sites, highest average density was found in site-I (1.72±0.86 per sq. m), while lowest (0.72±0.12 per sq. m) in site-VI (Table IV). Highest average frequency of herbs was recorded in site-II (59.52±3.36), whereas lowest average frequency of herbs (39.58±6.88) was found in study site-I (Table IV). Out of the 23 herb species, *Carthamus oxyacantha* was found in all sampling sites with variable density and frequency. *Saccharum spontaneum* was found in six sites, *Chenopodium album* in five and *Helioscopia europa* in four sampling sites. *Xanthium strumarium, Typha latifolia, Asphodelus tenuifolius, Verbena, officinalis, Xanthium strumarium, Typha latifolia Asphodelus tenuifolius, Verbena officlantis, Sonchus asper, Conyza canadensis,* were found in three different sites each. *Triticum aestivum, Amaranthus virdics* and *Tabulus taristis* were found in two sites. *Anagallis arvensis, Desmastacia bipinata, Fumaria indica, Malvastrum coromandelianum, Parthanium*

Table II.- Density (per hectare), frequency, relative dominance and IVI of the tree species at different study sites in district Chakwal during the current study period.

Site No.	Sr. No	Scientific name	D / ha	R D	F	R F	RD	IVI
I	1	*Acacia modesta*	0.40	4.13	16.66	6.25	2.89	13.27
	2	*Acacia nilotica*	3.63	37.53	100.0	37.49	43.47	118.49
	3	*Zizyphus mauritiana*	4.44	45.91	100.0	37.49	39.13	122.53
	4	*Dalbergia sissoo*	0.80	8.27	33.33	12.49	13.04	33.80
	5	*Tamarix aphylla*	0.40	4.13	16.66	6.25	1.44	11.82
		Mean	**1.93±0.87**	**19.99±8.99**	**53.33±19.29**	**19.99±7.23**	**19.99±8.95**	**59.98±25.02**
II	6	*Acacia modesta*	1.03	12.50	50.00	16.66	1.45	30.61
	7	*Acacia nilotica*	3.09	37.50	100.00	33.33	7.27	78.10
	8	*Zizyphus mauritiana*	2.40	29.16	88.33	27.78	87.27	144.23
	9	*Dalbergia sissoo*	1.03	12.50	33.33	11.11	2.90	26.51
	10	*Melia azadarach*	0.69	8.33	33.33	11.11	1.09	20.53
		Mean	1.64±**0.46**	**19.99±5.65**	60.99±**14.0**	19.99±**4.51**	19.99±**16.85**	**59.99±23.42**
III	11	*Acacia modesta*	0.84	8.32	33.33	12.50	5.55	26.37
	12	*Acacia nilotica*	4.20	41.58	83.33	33.12	55.55	130.25
	13	*Zizyphus mauritiana*	3.37	33.33	100.0	37.50	27.77	98.60
	14	*Eucalyptus globules*	0.42	4.16	16.66	6.24	2.77	13.17
	15	*Tamarix aphylla*	0.84	8.31	16.66	6.24	4.16	18.71
	16	*Melia azadarach*	0.42	4.16	16.66	6.24	4.16	14.56
		Mean	1.64±**0.46**	**19.99±5.65**	60.99±**14.0**	19.99±**4.51**	19.99±**16.85**	**59.99±23.42**
IV	17	*Acacia modesta*	1.65	20.88	50.00	18.75	15.00	54.63
	18	*Acacia nilotica*	2.30	29.16	88.33	31.25	50.00	110.41
	19	*Zizyphus mauritiana*	3.29	41.66	100.00	37.50	41.66	120.82
	20	*Morus alba*	0.33	4.17	16.66	6.25	4.66	15.42
	21	*Eucalyptus globulus*	0.33	4.17	16.66	6.25	5.00	15.42
		Mean	1.58±**0.57**	20.0±**7.26**	54.33±**17.46**	20.0±**6.37**	23.26±**9.49**	**63.34±22.56**
V	22	*Acacia modesta*	13.83	58.35	100.00	42.86	47.90	149.11
	23	*Acacia nilotica*	2.96	12.50	50.00	21.43	17.96	51.89
	24	*Dalbergia sissoo*	0.99	4.17	16.66	7.14	4.79	16.10
	25	*Eucalyptus globulus*	0.99	4.17	16.66	7.14	5.38	16.69
	26	*Melia azadarach*	0.99	4.17	16.66	7.14	17.96	2927
	27	*Olea ferruginea*	3.95	16.66	33.33	14.28	5.98	36.92
		Mean	**3.95±2.04**	**16.67±8.60**	**38.88±13.38**	**16.66±5.73**	**16.66±6.73**	**49.99±20.56**
VI	28	*Acacia modesta*	1.97	24.93	83.33	26.32	13.89	65.14
	29	*Acacia nilotica*	2.96	37.46	100.0	31.58	41.67	110.64
	30	*Zizyphus mauritiana*	0.33	4.18	16.66	5.26	2.78	12.22
	31	*Dalbergia sissoo*	1.65	20.88	66.66	21.05	27.78	69.71
	32	*Eucalyptus globulus*	0.33	4.18	16.66	5.26	4.17	13.61
	33	*Melia azadarach*	0.66	8.35	33.33	10.53	9.72	28.60
		Mean	1.31±**0.43**	16.66±**5.47**	52.77±**14.54**	16.66±**4.59**	16.66±**6.20**	**49.98±15.81**
VII	34	*Acacia modesta*	2.40	37.50	100.0	37.08	27.03	101.60
	35	*Acacia nilotica*	1.87	29.21	66.66	24.72	27.03	80.96
	36	*Zizyphus mauritiana*	1.87	29.21	88.33	32.75	40.54	102.50
	37	*Melia azadarach*	0.26	4.06	16.66	6.17	5.40	15.63
		Mean	1.60±**0.46**	24.99±**7.24**	67.91±**18.42**	25.18±**6.83**	25.0±**7.26**	**75.17±20.46**
VIII	38	*Acacia nilotica*	3.36	45.90	100.0	39.22	43.48	128.60
	39	*Zizyphus mauritiana*	2.74	37.43	83.33	34.64	32.61	104.8
	40	*Dalbergia sissoo*	0.92	12.56	50.00	19.61	21.74	53.91
	41	*Melia azadarach*	0.30	4.09	16.66	6.53	2.17	12.79
		Mean	1.83±**0.72**	24.99±**9.93**	62.49±**18.47**	25.0±**7.44**	25.0±**8.80**	**75.02±25.94**

*D**,** density of plant species; RD, relative density; F, frequency; RF, relative frequency; RD, relative dominance; IVI, importance value index.

Table III.- Density and frequency of shrub species occurring in different study sites of Chakwal district during the study period from May 2009 to June 2010.

Study sites	Shrub species	D/4m^2	F
I	*Zizyphus nummularia*	0.66	50
	Capparis decidua	0.33	33.33
	Prosopis juliflora	0.83	66.66
	Calotropis procera	0.66	33.33
	Saccharum griffithii	0.33	33.33
	Mean	**0.56±0.09**	**43.33±6.66**
II	*Calotropis procera*	0.66	50
	Prosopis juliflora	0.33	16.66
	Saccharum griffithii	0.66	33.33
	Zizyphus nummularia	0.66	33.33
	Mean	**0.57±0.08**	**33.33±6.80**
III	*Capparis decidua*	0.33	33.33
	Prosopis juliflora	0.66	50
	Zizyphus nummularia	0.83	33.33
	Adhatoda vasica	0.33	33.33
	Mean	**0.53±0.12**	**37.49±4.16**
IV	*Prosopis juliflora*	1	50
	Calotropis procera	0.33	33.33
	Saccharum griffithii	0.5	33.33
	Ricinus communis	1	33.33
	Capparis decidua	0.5	50
	Mean	**0.66±0.13**	**39.99±4.08**
V	*Justicia adhatoda*	0.33	33.33
	Dodonaea viscosa	1.5	83.33
	Cannabis sativa	1.17	50
	Adhatoda vasica	0.5	50
	Ziziphus nummularia	0.33	33.33
	Mean	**0.76±0.24**	**49.99±9.12**
VI	*Calotropis procera*	0.66	50
	Cannabis sativa	1	50
	Adhatoda vasica	0.66	50
	Zizyphus nummularia	0.5	33.33
	Mean	**0.70±0.10**	**45.83±4.16**
VII	*Zizyphus nummularia*	1	50
	Justicia adhatoda	0.66	50
	Calotropis procera	0.5	33.33
	Prosopis juliflora	0.5	33.33
	Mean	**0.66±0.11**	**41.67±4.81**
VIII	*Zizyphus nummularia*	0.33	33.33
	Saccharum griffithii	0.66	50
	Calotropis procera	0.83	50
	Mean	**0.60±0.14**	**44.44±5.55**

*D, density; F, frequency.

hysterophorous and, *Medicago polymorpha* were found in one site each (Table IV).

Population estimates

Among the three falcon species recorded, average population density of red-headed merlin during the current study period was 0.238 ± 0.06 birds/ km^2, common kestrel 0.246 ±0.05 birds/ km^2 and saker falcon 0.245 ± 0.06 birds/ km^2 (Fig. 4).

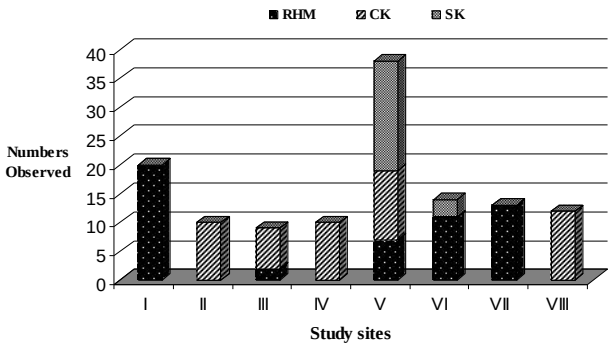

Fig. 3. Numbers (n) of birds of three falcon species sighted in various selected transects during the study period from May 2009 to June 2010.*RHM, red-headed merlin; CK, common kestrel; SK, saker falcon

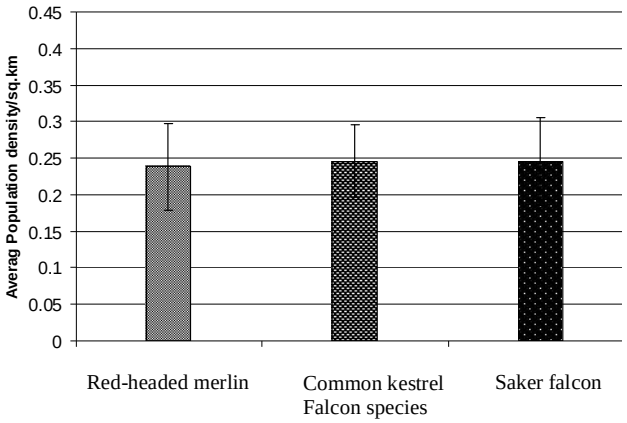

Fig. 4. Average density (per Km^2) of three species of falcons in selected sites of district Chakwal from May 2009 to June 2010. Values are as mean±SE.

Red-headed merlin

A total number of 53 sightings of this falcon species were recorded during the whole study period in five of the eight selected sites; I, III, V, VI and VII (Fig. 3). However, sites II, IV and VIII did not witness any bird of this species. Its maximum sightings were recorded in site I (n =20), and minimum in site III (n = 2). Thus, the highest average density of this falcon species was found in sampling site I (0.45± 0.09 /km^2) and lowest in site III (0.04±0.03 / km^2) (Table V).

In sampling site-I, maximum of four birds were observed at one time and one bird found dead on 20 June 2009 was found to be electrocuted.

Table IV. Density (/m^2) and frequency of herb species occurring at eight different study sites in Chakwal district during the study period from May 2009 to June 2010.

Study sites	Shrub species	D/4m^2	F
I	*Carthamus oxyacantha*	1.2	66.66
	Helioscopia europa	1.3	66.66
	Xanthium strumarium	0.3	16.66
	Typha latifolia	0.8	16.66
	Triticum aestivum	6.7	33.33
	Asphodelus tenuifolius	1.5	33.33
	Anagallis arvensis	0.2	16.66
	Desmastacia bipinata	1.8	66.66
	Mean	**1.72±0.86**	**39.57±6.88**
II	*Carthamus oxyacantha*	1.5	66.66
	Helioscopia europa	1.2	66.66
	Asphodelus tenuifolius	1.8	66.66
	Saccharum spontaneum	1.8	50.00
	Fumaria indica	1.3	66.66
	Chenopodium album	0.8	50.00
	Crisium aruense	0.5	50.00
	Mean	**1.27±0.18**	**59.52±3.36**
III	*Carthamus oxyacantha*	1.2	66.66
	Helioscopia europa	0.5	50.00
	Desmastacia bipinata	1.5	83.33
	Fumaria indica	0.3	33.33
	Saccharum spontaneum	2.2	83.33
	Verbena officinalis	0.7	50.00
	Sonchus asper	1.3	66.66
	Conyza Canadensis	0.5	33.33
	Mean	**1.02±0.22**	**58.33±7.04**
IV	*Carthamus oxyacantha*	1.3	83.33
	Helioscopia europa	0.7	50.00
	Saccharum spontaneum	2	83.33
	Verbena officinalis	0.7	66.66
	Sonchus asper	0.7	50.00
	Typha latifolia	1.8	33.33
	Xanthium strumarium	0.5	50.00
	Amaranthus virdics	0.7	50.00
	Mean	**1.05±0.20**	**58.33±6.29**
V	*Carthamus oxyacantha*	1.3	66.66
	Tabulus taristis	0.7	50.00
	Xanthium strumarium	0.5	50.00
	Conyza Canadensis	0.66	50.00
	Chenopodium album	0.5	50.00
	Amaranthus virdics	0.7	50.00
	Saccharum spontaneum	1.5	66.66
	Mean	**0.83±0.15**	**54.76±3.07**
VI	*Carthamus oxyacantha*	1.2	50.00
	Typha latifolia	0.8	33.33
	Xanthium strumarium	0.5	50.00
	Saccharum spontaneum	1.3	66.66
	Bidens biternata	0.3	33.33
	Chenopodium album	0.7	50.00
	Euphorbia helioscopia	0.5	50.00
	Malvastrum coromandelianum	0.5	33.33
	Mean	**0.72±0.12**	**45.83±4.16**
VII	*Carthamus oxyacantha*	1.2	66.66
	Triticum aestivum	5.2	33.33
	Asphodelus tenuifolius	1.5	83.33
	Parthanium hysterophrous	0.8	50.00
	Amaranthus virdics	0.5	50.00
	Chenopodium album	0.7	50.00
	Conyza Canadensis	0.3	33.33
	Mean	**1.45±0.64**	**52.37±6.73**
VIII	*Carthamus oxyacantha*	1.3	50.00
	Saccharum spontaneum	1.5	83.33
	Amaranthus virdics	0.5	33.33
	Chenopodium album	0.7	50.00
	Verbena officinalis	0.5	50.00
	Tabulus taristis	0.5	33.33
	Medicago polymorpha	1.8	66.66
	Sonchus asper	0.7	50.00
	Mean	**0.93±0.18**	**52.08±5.83**

*D, density; F, frequency.

In site-VI, one nest and two nestlings were also reported by a local resident; however, the nest got burnt when fire broke out in the eastern slope of the study area, on an *Acacia* tree. Estimates of population density of red-headed merlin in different study sites were analyzed statistically by using one-way Analysis of Variance (ANOVA) and there were found a significant difference ($p < 0.001$) among various sites (Table VI).

Common kestrel

Common kestrel was identified in five study sites; II, III, IV, V and VIII (Table V) and a total 51 sightings of this species were recorded (Fig.3). Study sites V and VIII had maximum sightings (n = 12 each), followed by site II and IV (n =10 each). Average density of common kestrel was found highest in study site VIII (0.29±0.05/km^2), while sites II, III, IV and V had moderate density values for this species (Table V).

No sightings of this species were possible from May 2009 to August 2009. The first common kestrel was observed in September 2009 flying over a peanut field. Later, it was observed regularly in the sampling sites. In site-III, common kestrel was first time observed in November 2009. In site IV, evidence of breeding activity of common kestrel was found. Statistical analysis of population estimates of common kestrel during the study period by one-way analysis of variance showed non-significant difference ($p = 0.737$) in the selected sites (Table VI).

Table V. Population densities (/km^2) of the three falcon species in eight different selected sites of the district Chakwal from May 2009 to June 2010.

Months	Study sites											
	I	II	III		IV	V			VI		VII	VIII
	RHM	CK	RHM	CK	CK	RHM	CK	SF	RHM	SF	RHM	CK
May 09	1.25	-	-	-	-	-	-	-	-	-	-	-
Jun	0.94	-	0.31	-	-	-	-	-	0.31	-	-	-
Jul	-	-	-	-	-	-	-	-	-	-	0.63	0.31
Aug	0.31	-	0.31	-	-	0.31	-	0.31	0.31	-	0.31	-
Sep	0.31	0.31	-	-	-	0.31	-	0.63	0.31	0.31	0.31	-
Oct	0.31	0.31	-	-	0.31	-	-	0.63	-	-	-	0.63
Nov	0.31	0.31	-	0.31	0.31	-	0.31	-	0.63	-	0.31	0.63
Dec	0.63	0.63	-	0.31	0.63	-	0.31	0.31	-	-	0.94	0.31
Jan	0.31	0.31	-	-	-	0.31	0.31	0.63	-	-	0.31	0.31
Feb	-	0.31	-	0.63	0.31	0.63	-	0.31	0.31	0.31	-	0.31
Mar	0.31	0.63	-	0.31	0.31	-	0.31	0.94	-	-	0.31	0.31
Apr	0.63	0.31	-	0.31	-	0.31	1.30	0.63	0.63	0.31	-	0.63
May	0.63	0.31	-	0.31	0.63	0.31	0.63	0.63	0.63	-	0.63	0.31
Jun-10	0.31	-	-	-	0.63	-	0.31	0.94	0.31	-	0.31	0.31
Total	**6.25**	**3.43**	**0.62**	**3.13**	**3.13**	**2.18**	**3.48**	**5.96**	**3.44**	**0.93**	**4.05**	**4.06**
Mean	**0.45± 0.09**	**0.25±0.05**	**0.04±0.03**	**0.22±0.05**	**0.22±0.06**	**0.16±0.05**	**0.25±0.10**	**0.42±0.09**	**0.25±0.06**	**0.07±0.03**	**0.29±0.07**	**0.29±0.05**

*RHK; Red-headed merlin; CK, Common kestrel; SF, Saker falcon.

Table VI.- One-way Analysis of Variance (ANOVA) of population estimates of three falcon species in the study area from May 2009 to June 2010.

Falcon species	Study sites								df	*F* Value	*p* Value
	I	II	III	IV	V	VI	VII	VIII			
Red-headed merlin											
Sum	6.25	-	0.62	-	2.18	3.44	4.06	-	69	4.99	$p < 0.001$
Average	0.45	-	0.04	-	0.16	0.25	0.29	-			
Variance	0.116	-	0.012	-	0.041	0.063	0.082	-			
Common kestrel											
Sum	-	3.43	2.18	3.13	3.48	-	-	4.06	69	0.606	$p = 0.737$
Average	-	0.245	0.155	0.22	0.24	-	-	0.29			
Variance	-	0.048	0.041	0.067	0.130	-	-	0.052			
Saker falcon											
Sum	-	-	-	-	5.96	0.93	-	-	27	13.58	$p < 0.001$
Average	-	-	-	-	0.43	0.07	-	-			
Variance	-	-	-	-	0.115	0.017	-	-			

Saker falcon

Saker Falcon was found inhabiting only two selected sites; site-V and VI (Fig. 3). Its maximum sightings were recorded in site V (n=19), while very low in site VI (n=3). Site V had a density of $0.42\pm0.09/km^2$, while site VI had a value of $0.07\pm0.03/km^2$.

A saker falcon was sighted for the first time in August 2009 in site-V. Presence of nests and breeding activity of saker falcon were also reported by a local resident in the previous year (2008). Saker falcon was also observed in its nesting site on the hill (Karangli hill). A pair of this species used to roost up on this hill side at night. A single saker falcon was observed flying over the nearby village "Vahali", where it preyed upon domestic pigeons. Estimates of population density of saker falcon were analyzed statistically by using one-way analysis of variance (ANOVA) and there were found a significant differences ($p<0.001$) among various sites (Table VI).

DISCUSSION

The current study focused little studied group of birds; falcons in a representative area (Chakwal District) of Potohar Plateau in Pakistan. This particular district (covering an area of 6524 km^2 including 5 Tehsils (small administrative units of the district) has rich diversity of fauna and flora due to its unique location. As a result it shares a number of animal species of the two ranges.

In Pakistan, very little studies exist about falcon species, a few have addressed their role as indicator species in heavy metal pollution (Movalli, 2000; Nighat *et al.*, 2010 unpublished thesis). But as far as their habitat and population status is concerned, the authors could find no studies in this particular area.

The three falcon species present in the study region; red-headed merlin, common kestrel and saker falcon were found specifically associated with particular features of the habitat. Red-headed merlin was associated with habitats having *Acacia nilotica* tree (sites I and VII) for roosting and it also utilized the nests of other birds which were constructed on this particular tree species. Both active nests used by red-headed merlin (in site-I and VII) were found on *Acacia nilotica* trees. Common kestrel had preference for habitats having *Tamarix aphylla* trees for roosting and utilization of nests. Saker falcon inhabited the areas located at relatively high altitudes such as in sites V and VI, having small hills with cliffs, approximately 600m high from ground levels as compared to other sites. The nests of saker falcon were situated inside the cavities and two such active nests (one each) were discovered in site V and VI.

Habitat evaluation of selected sites during the current study showed 9 different tree species occurring in varying frequencies. Among those, *Acacia modesta* was found in seven sites, whereas *Acacia nilotica* was found in all eight study sites, site-V had a relatively low IVI (51.89), while remaining seven sites had high values of IVI ranging from 78.10 to 130.25. Red-headed merlin occurred at five study sites-I, III, V, VI and VII, all having *Acacia nilotica* trees and it stayed the same habitats throughout the study period, confirming its breeding activity in these sites in the form of fledglings. According to Roberts (1991), red-headed merlin repairs and utilizes the old nests of crows and kites and in this context *Acacia* trees are favored. In the current study, this falcon species showed a nesting preference for *Acacia nilotica.* Site-I, had IVI for *Acacia nilotica* (118.49), site III (130.25), site V (51.89), site-VI (110.64) and in site-VII the IVI value for *Acacia nilotica* was 80.96. The presence of falcon species in these sites with high IVI values indicates preference of red-headed merlin for this plant species, which apparently seems to provide roosting and nesting sites to this raptor species. In addition, study sites I and VI were also utilized by this falcon species for its breeding activity since its both nests were constructed on *Acacia nilotica* tree; one in site I and the other in site II. Moreover, one of the fledgling of red-headed merlin was observed sitting on a branch near an active nest in site I (Fig.5). These results confirm the breeding activity of red-headed merlin in the study area.

Vegetation not only provides animals with hiding places, but also obstructs vision, reduces detection of predators, and hinders escape (Lima 1987, 1990; Schooley *et al.*, 1996; Blumstein *et al.*, 2004). Predation risk increases in open habitats

compared with that of bush habitats (Longland and Price, 1991), as well as in patches without grass cover (Wywialowski, 1987). Both social and solitary rodents are less wary when in patches with high plant cover (Cassini, 1991; Sharpe and Van Horne, 1998). In the eight selected sites, *Ziziphus nummularia* and *Calotropis procera* represented major shrub species in the falcon's habitat. Sites I, II and VIII had high average density values for shrubs. According to Barnard (1980), Leger *et al*. (1983); Cassini (1991), Otter (1994), Tchabovsky *et al*. (2001), small mammals and birds spend more time alert when foraging away from shrubs or tree cover. Selection of thick vegetation is considered to be an anti-predatory strategy against both aerial (Longland and Price, 1991) and terrestrial (Jedrzejewska and Jedrzejewski, 1990) predators. In the current study, shrub species in the selected sites are indicative of providing escape cover to birds and small mammals; the prey species for the falcons. As described by Kotler and Brown (1988) a number of small mammal communities show preference for habitats with high amount of vegetation cover and probably this is the reason why population of falcons was high in some sites like I, II, IV and V.

Various herb species found in the selected sites were providing feeding sites and escape cover to the small mammals and birds which in turn served as prey for the falcons. In addition, sites I, VI and VII had cultivated fields of wheat as well, which are obviously utilized by rodents (granivorous) for obtaining their nutrition. Since red-headed merlin preys upon rodents, that is why these three habitat sites were favored and preferred by red-headed merlin species.

Common kestrel is largely resident and breeds in the mountains of Pakistan, winter migrating populations avoid well wooded and cultivated tracts and prefer 'barani.' or dry foot hill zone. It prefers to nest on cliff ledges and some tall trees (Roberts, 1991). In the present study, occurrence of common kestrel was recorded in five sites; II, III, IV, V and VIII; these were mostly cultivated fields with low tree density. However, *Zizyphus mauritiana, Acacia nilotica, Acacia modesta, Melia azedarach* and *Tamarix aphylla* trees were found in these sites. It shows that common kestrel utilizes cultivated open areas. All trees occurring in these sites were found to be utilized by common kestrel for roosting and perching and they also provided suitable habitat for other bird species, which serve as a food source (prey) for common kestrel.

Population estimates of three falcon species in the study region have shown red-headed merlin and common kestrel occurring in most study sites (six) whereas saker falcon was limited to only two sites. Average population density of red-headed merlin was least (0.238 ± 0.06 birds /km^2) among the three falcon species studied here, however, this species was sighted regularly throughout the year which indicates it is a resident species here with breeding evidence. Maximum sightings during current study period were recorded for red-headed merlin (n = 20) and then for Saker falcon (n = 19) while common kestrel was least sighted (n = 10) among the three species. Red-headed merlin is usually found in a number of large protected areas world-wide, and its global population estimates in 2009 were 10,000 to 100,000 mature pairs (Bird Life International, 2010). It has been categorized as "Least Concern" in the Red list of threatened species. It is native to Pakistan but has become extinct from Iran (IUCN, 2010). It is listed in Appendix-II of the CITES (CITES, 2010). Due to this reason, its population in Pakistan needs to be monitored regularly. In the current study, a total of 53 sightings of Red-headed merlin were recorded from May 2009 to June 2010 with maximum average density in site-I (0.45 ± 0.09/ km^2) while minimum in site-III (0.04 ± 0.03 /km^2). Since no previous density estimates of falcons are available at the moment from any region of Pakistan, therefore, it is not possible to make a comparison about their population trend.

According to IUCN Red List Criterion of Threatened species, common kestrel is also listed as "Least Concern" (LC) in the assessed year 2009. It is native to Pakistan, and prefers terrestrial habitat (IUCN, 2010) and its global population estimated is approximately 5,000,000. It is listed in Appendix- II on CITES (CITES, 2010). During the current study period, Common kestrel was found in five sites (II, III, IV, V and VIII) but its population density was very low. Maximum number of this species observed at one time were two. According to

Naoroji (2006), common kestrel is a regular winter visitor throughout the sub-continent and breeds commonly in Pakistan. The results of current study show that after winter, 2- 4 birds were observed in study site-V in April, May and June 2010 (which is its breeding period). Its presence during these months is indicative of its breeding activity in the area. So it is suggested that this falcon species is not only winter migrant but also breeds here. Evidence of one active nest (in site-IV) utilized by common kestrel supports the activity of breeding of this species. However, later increase in its winter population indicates addition of winter visitors to the existing population in the study area. Results of the present study show that common kestrel is a winter visitor as well as resident to the study area.

The saker falcon was recorded in only two sites (V and VI) of the study area during the present study period. According to IUCN Red list criterion, saker falcon is listed as "Endangered" and is included in Appendix-II under CITES. Its global population estimates were just 8,500-12,000 pairs in 1990, compared to 3,600 - 4,400 pairs in the year 2003. Most recent estimates of its global population are between 9,400-17,700 breeding pairs (Dixon, 2007, 2009). These records show that population of saker falcon has been declining (BirdLife International. 2010). As described by Roberts (1991) saker falcon is a winter visitor both in the mountainous regions and the foothills of Mianwali, Kohat and Attock districts in Pakistan. During current study period, this species was recorded in "Karangli hill" site (V) of the study area, located at a height of 1042 m in the foot hills of Salt Range near Kallar Kahar. Saker falcon was regularly sighted in pairs in this particular site, where seven nests were also found located in the cliff ledge. Reports (with evidence from local informants) about the breeding of saker falcon reveal that it is a resident bird in the study area that also has been found to breed occasionally in the Karangli hill for a number of years.

The study concludes that district Chakwal harbors three falcon species; Red-headed merlin, common kestrel and saker falcon, which occur in various parts of the district in varying densities. The three falcon species have got specific habitat requirements in the form of tree, shrub and herb species which are very vital for maintenance of their populations in the study area. Low population densities of these three falcon species in the study region demand regular monitoring of their populations.

Threats to falcon species and recommendations

A number of threats are posed to these three falcon species in this particular region; during current study period, it was noticeable that local people cut down and sale out the old and large *Acacia nilotica* trees, and at least twenty such large *Acacia* trees were found cut by these traders during different visits to the study sites. Cutting of large trees in the study area will ultimately affect population of falcon species negatively since this tree species is most preferred by red-headed merlin for roosting and nesting. Similarly, another major threat, especially to saker falcon is "shooting" by local hunters who think that this falcon species preys and feeds upon their pigeons which they keep as pets. Moreover, maintenance of populations of other birds as well as rodent species in the study area is also very vital since these falcon species reportedly feed chiefly on these two prey items. Therefore, it is recommended that local residents of the area must be educated about the ecological importance of the falcons found therein, so that they do not steal the young ones of these falcons and also do not shoot them. Tree cutting (especially of *Acacia nilotica*) should be strictly checked and banned since a decline in numbers of this tree species will affect falcon populations.

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(Received 8 March 2011, revised 25 March 2011)